FOR ORBIT INSIDE EARTH'S
MAGNETOSPHERE, START
HERE:

FOR ORBITS AT OR BEYOND
GEOSYNCHRONOUS, START
HERE:

AUXILIARY PROGRAMS YOU
MAY WISH TO RUN:

GTRN:

EVALUATES
GEOMAGNETIC SHIELDING

200

FLUX:

EVALUATES FLUXES AT EXTERNAL
SURFACE OF SPACECRAFT

100

TRANS:

TRANSPORTS NUCLEI
THROUGH SHIELDING

300

SHIELDFILE:

FORMATES USER-SUPPLIED
SHIELDING DISTRIBUTION FOR
INPUT TO TRANS

400

PUP:

PROTON-INDUCED
SEU RATES

500

LET:

CALCULATES
LINEAR ENERGY
TRANSFER (LET)
SPECTRA

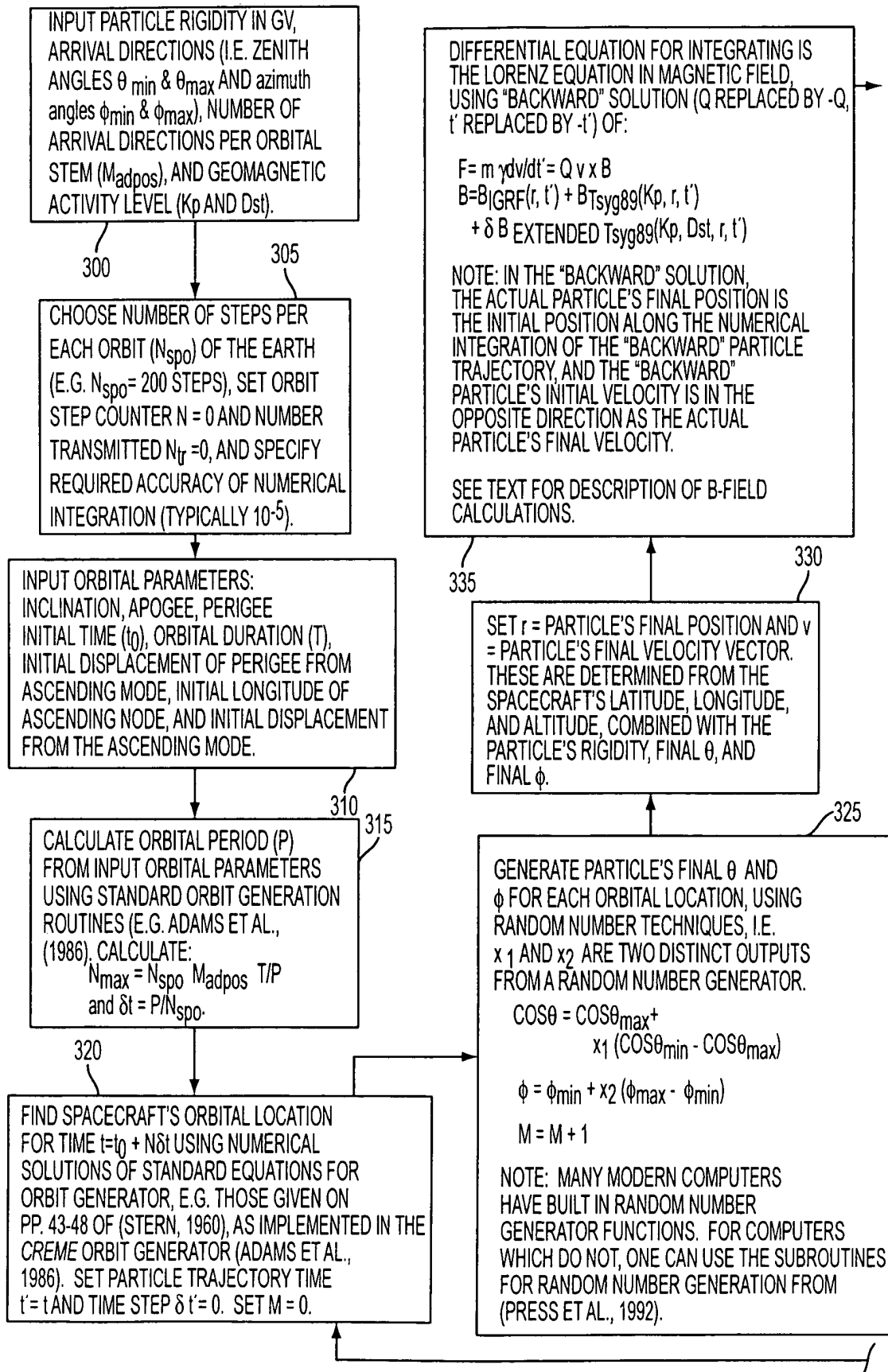600
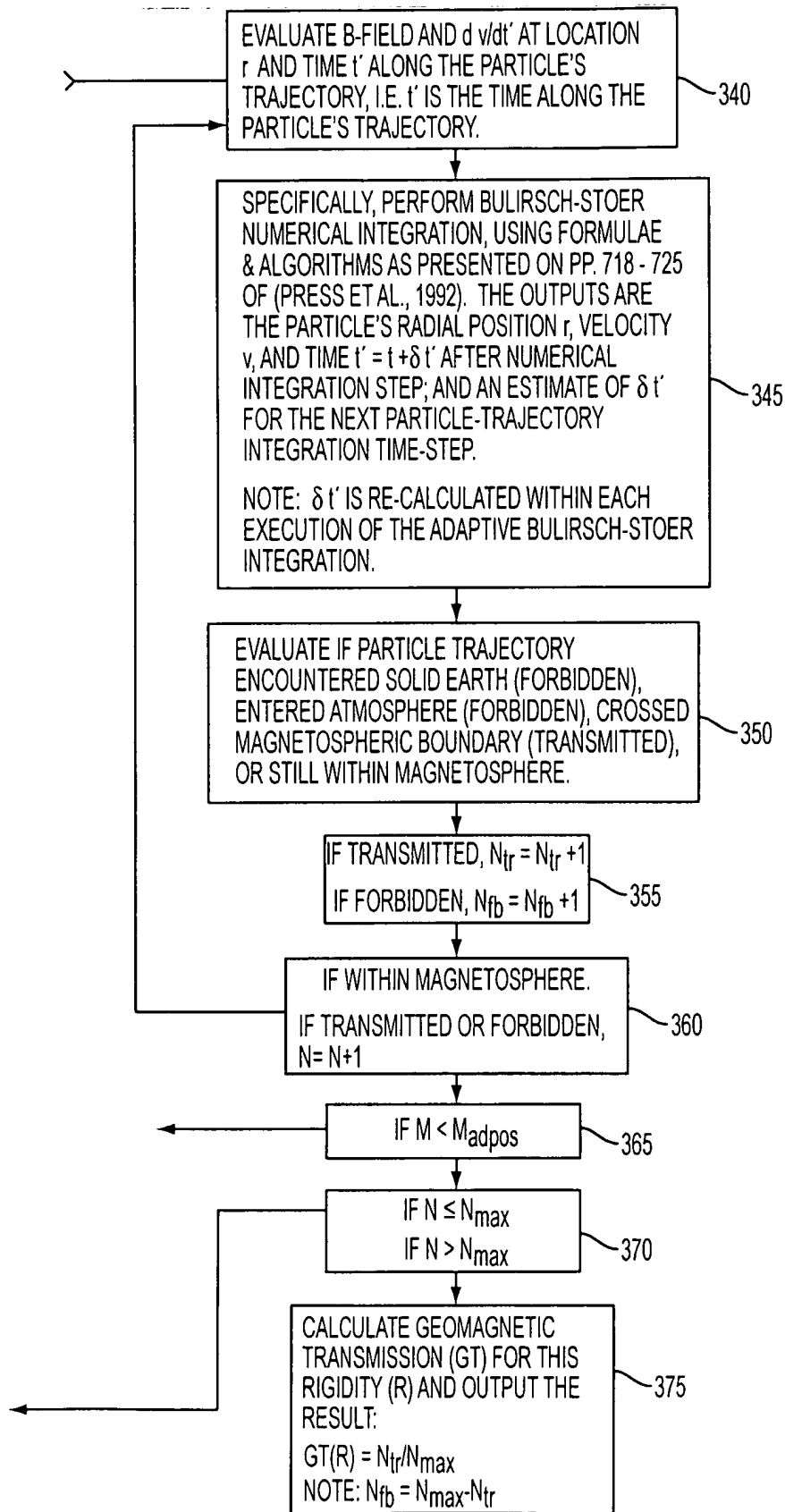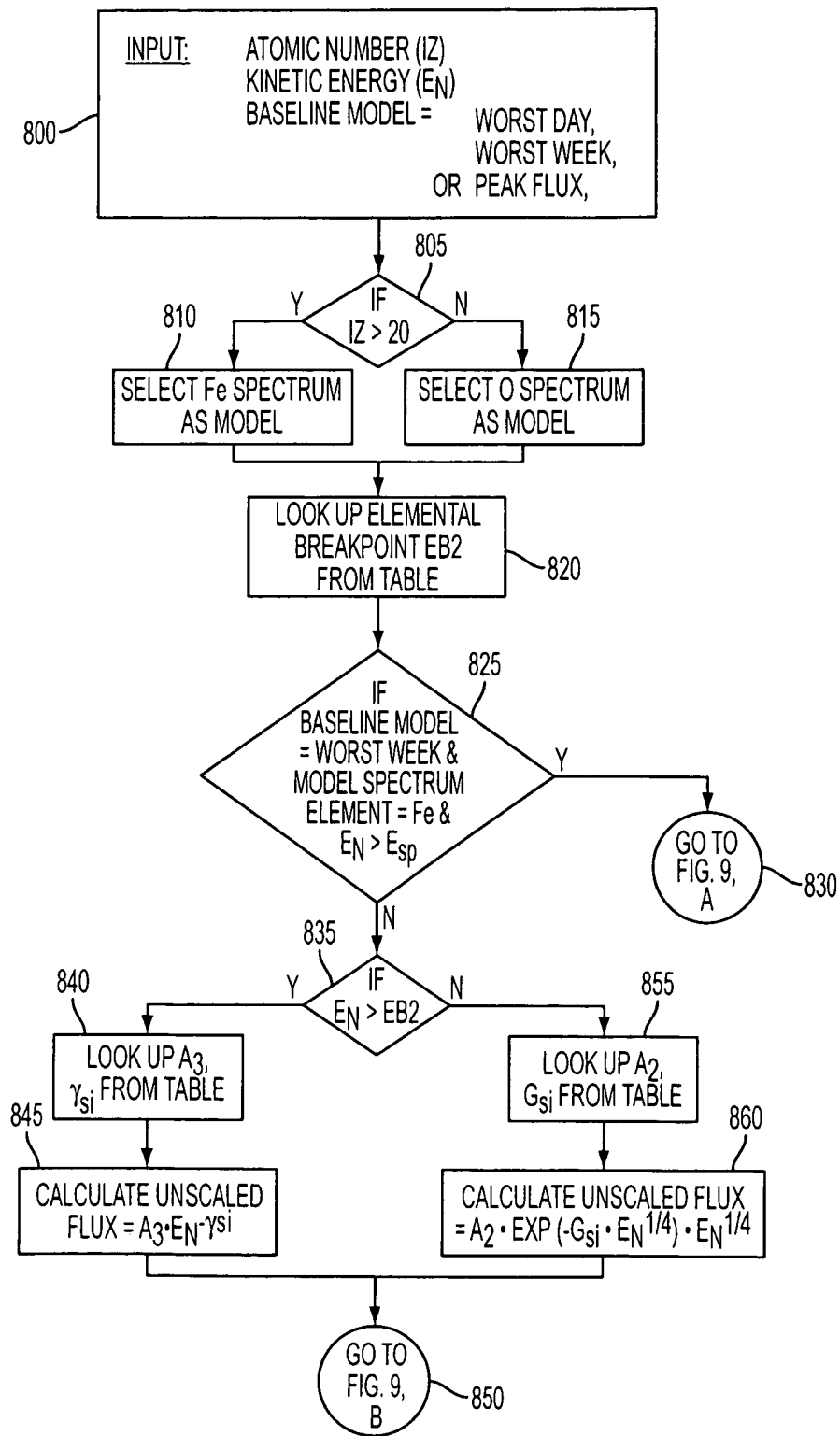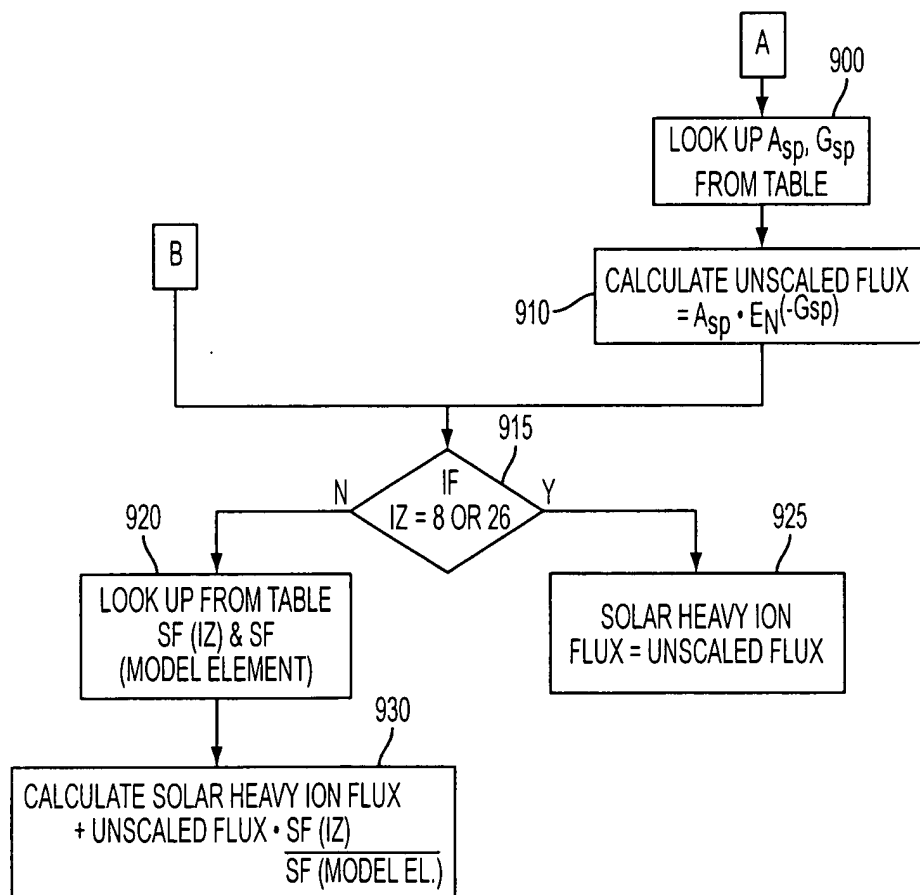
HUP:

DIRECT-IONIZATION
INDUCED SEU
RATES

700

FIG. 1

INPUT PARTICLE RIGIDITY IN GV, ARRIVAL DIRECTIONS (I.E. ZENITH ANGLES θ_{min} & θ_{max} AND azimuth angles ϕ_{min} & ϕ_{max}), NUMBER OF ARRIVAL DIRECTIONS PER ORBITAL STEM (M_{adpos}), AND GEOMAGNETIC ACTIVITY LEVEL (Kp AND Dst).

300 305

CHOOSE NUMBER OF STEPS PER EACH ORBIT (N_{spo}) OF THE EARTH (E.G. N_{spo}= 200 STEPS), SET ORBIT STEP COUNTER N = 0 AND NUMBER TRANSMITTED N_{tr} =0, AND SPECIFY REQUIRED ACCURACY OF NUMERICAL INTEGRATION (TYPICALLY 10^{-5}).

INPUT ORBITAL PARAMETERS: INCLINATION, APOGEE, PERIGEE INITIAL TIME (t_0), ORBITAL DURATION (T), INITIAL DISPLACEMENT OF PERIGEE FROM ASCENDING MODE, INITIAL LONGITUDE OF ASCENDING NODE, AND INITIAL DISPLACEMENT FROM THE ASCENDING MODE.

310 315

CALCULATE ORBITAL PERIOD (P) FROM INPUT ORBITAL PARAMETERS USING STANDARD ORBIT GENERATION ROUTINES (E.G. ADAMS ET AL., (1986). CALCULATE:
$$N_{max} = N_{spo}\, M_{adpos}\, T/P$$
and $\delta t = P/N_{spo}$.

320

FIND SPACECRAFT'S ORBITAL LOCATION FOR TIME t=t_0 + Nδt USING NUMERICAL SOLUTIONS OF STANDARD EQUATIONS FOR ORBIT GENERATOR, E.G. THOSE GIVEN ON PP. 43-48 OF (STERN, 1960), AS IMPLEMENTED IN THE *CREME* ORBIT GENERATOR (ADAMS ET AL., 1986). SET PARTICLE TRAJECTORY TIME t'= t AND TIME STEP δ t'= 0. SET M = 0.

DIFFERENTIAL EQUATION FOR INTEGRATING IS THE LORENZ EQUATION IN MAGNETIC FIELD, USING "BACKWARD" SOLUTION (Q REPLACED BY -Q, t' REPLACED BY -t') OF:

$$F= m\, \gamma dv/dt' = Q\, v \times B$$
$$B=B_{IGRF}(r, t') + B_{Tsyg89}(Kp, r, t')$$
$$+\, \delta B_{EXTENDED\ Tsyg89}(Kp, Dst, r, t')$$

NOTE: IN THE "BACKWARD" SOLUTION, THE ACTUAL PARTICLE'S FINAL POSITION IS THE INITIAL POSITION ALONG THE NUMERICAL INTEGRATION OF THE "BACKWARD" PARTICLE TRAJECTORY, AND THE "BACKWARD" PARTICLE'S INITIAL VELOCITY IS IN THE OPPOSITE DIRECTION AS THE ACTUAL PARTICLE'S FINAL VELOCITY.

SEE TEXT FOR DESCRIPTION OF B-FIELD CALCULATIONS.

335 330

SET r = PARTICLE'S FINAL POSITION AND v = PARTICLE'S FINAL VELOCITY VECTOR. THESE ARE DETERMINED FROM THE SPACECRAFT'S LATITUDE, LONGITUDE, AND ALTITUDE, COMBINED WITH THE PARTICLE'S RIGIDITY, FINAL θ, AND FINAL ϕ.

325

GENERATE PARTICLE'S FINAL θ AND ϕ FOR EACH ORBITAL LOCATION, USING RANDOM NUMBER TECHNIQUES, I.E. x_1 AND x_2 ARE TWO DISTINCT OUTPUTS FROM A RANDOM NUMBER GENERATOR.

$$COS\theta = COS\theta_{max} + x_1 (COS\theta_{min} - COS\theta_{max})$$

$$\phi = \phi_{min} + x_2 (\phi_{max} - \phi_{min})$$

$$M = M + 1$$

NOTE: MANY MODERN COMPUTERS HAVE BUILT IN RANDOM NUMBER GENERATOR FUNCTIONS. FOR COMPUTERS WHICH DO NOT, ONE CAN USE THE SUBROUTINES FOR RANDOM NUMBER GENERATION FROM (PRESS ET AL., 1992).

FIG. 3A

EVALUATE B-FIELD AND d v/dt' AT LOCATION r AND TIME t' ALONG THE PARTICLE'S TRAJECTORY, I.E. t' IS THE TIME ALONG THE PARTICLE'S TRAJECTORY. —340

SPECIFICALLY, PERFORM BULIRSCH-STOER NUMERICAL INTEGRATION, USING FORMULAE & ALGORITHMS AS PRESENTED ON PP. 718 - 725 OF (PRESS ET AL., 1992). THE OUTPUTS ARE THE PARTICLE'S RADIAL POSITION r, VELOCITY v, AND TIME $t' = t + \delta t'$ AFTER NUMERICAL INTEGRATION STEP; AND AN ESTIMATE OF $\delta t'$ FOR THE NEXT PARTICLE-TRAJECTORY INTEGRATION TIME-STEP. —345

NOTE: $\delta t'$ IS RE-CALCULATED WITHIN EACH EXECUTION OF THE ADAPTIVE BULIRSCH-STOER INTEGRATION.

EVALUATE IF PARTICLE TRAJECTORY ENCOUNTERED SOLID EARTH (FORBIDDEN), ENTERED ATMOSPHERE (FORBIDDEN), CROSSED MAGNETOSPHERIC BOUNDARY (TRANSMITTED), OR STILL WITHIN MAGNETOSPHERE. —350

IF TRANSMITTED, $N_{tr} = N_{tr} + 1$
IF FORBIDDEN, $N_{fb} = N_{fb} + 1$ —355

IF WITHIN MAGNETOSPHERE.
IF TRANSMITTED OR FORBIDDEN, N= N+1 —360

IF $M < M_{adpos}$ —365

IF $N \leq N_{max}$
IF $N > N_{max}$ —370

CALCULATE GEOMAGNETIC TRANSMISSION (GT) FOR THIS RIGIDITY (R) AND OUTPUT THE RESULT: —375
$GT(R) = N_{tr}/N_{max}$
NOTE: $N_{fb} = N_{max} - N_{tr}$

FIG. 3B

800 —

INPUT: ATOMIC NUMBER (IZ)
KINETIC ENERGY (E_N)
BASELINE MODEL =   WORST DAY,
WORST WEEK,
OR   PEAK FLUX,

805

IF
IZ > 20

810 — Y

815 — N

SELECT Fe SPECTRUM
AS MODEL

SELECT O SPECTRUM
AS MODEL

LOOK UP ELEMENTAL
BREAKPOINT EB2
FROM TABLE — 820

825

IF
BASELINE MODEL
= WORST WEEK &
MODEL SPECTRUM
ELEMENT = Fe &
$E_N > E_{sp}$

Y →

GO TO
FIG. 9,
A — 830

N

835

IF
$E_N > EB2$

840 — Y

855 — N

LOOK UP A_3,
γ_{si} FROM TABLE

LOOK UP A_2,
G_{si} FROM TABLE

845

860

CALCULATE UNSCALED
FLUX = $A_3 \cdot E_N^{-\gamma_{si}}$

CALCULATE UNSCALED FLUX
= $A_2 \cdot EXP(-G_{si} \cdot E_N^{1/4}) \cdot E_N^{1/4}$

GO TO
FIG. 9,
B — 850

FIG. 8

A   900

LOOK UP A_{sp}, G_{sp}
FROM TABLE

B

910 ⎯ CALCULATE UNSCALED FLUX
$= A_{sp} \cdot E_N^{(-Gsp)}$

915

N ⟵ IF
IZ = 8 OR 26 ⟶ Y

920

LOOK UP FROM TABLE
SF (IZ) & SF
(MODEL ELEMENT)

925

SOLAR HEAVY ION
FLUX = UNSCALED FLUX

930

CALCULATE SOLAR HEAVY ION FLUX
+ UNSCALED FLUX $\cdot \dfrac{SF\ (IZ)}{SF\ (MODEL\ EL.)}$

FIG. 9

CREME96 MAIN MENU

SEE BRIEF INSTRUCTION AT THE BOTTOM OF THIS PAGE. SEE HOW TO RUN CREME96 FOR MORE DETAILS

GO		RESET FORM	
ROUTINE	USER REQUEST FILE LIST	EDIT USER REQUEST FILE	RUN ROUTINE
TPS	[▼]	○	□
GTRN	[▼]	○	□
FLUX	[▼]	○	□
TRANS	[▼]	○	□
LETSPEC	[▼]	○	□
PUP	[▼]	○	□
HUP	[▼]	○	□
UTILITIES (CREATE PLOTS, PERFORM DOWNLOADS, ETC.)			□

1. TO CREATE A USER REQUEST FILE:
    CLICK ON THE EDIT BUTTON BY THE CORRESPONDING ROUTINE, LEAVING THE USER
    REQUEST FILE BLANK. (IF NECESSARY, USE THE BLANK SPACE IN THE PULLDOWN MENU
    TO CLEAR A NAME ALREADY TYPED THERE.)
    CLICK ON THE "GO" BAR.

2. TO EDIT AN EXISTING USER REQUEST FILE:
    CLICK ON THE EDIT BUTTON BY THE CORRESPONDING ROUTINE.
    SELECT A USER REQUEST FILE FROM THE APPROPRIATE PULL-DOWN MENU.
    CLICK ON THE "GO" BAR.

3. TO RUN ONE OR MORE ROUTINES:
    IF AN EDIT BUTTON HAS BEEN CLICKED "ON", USE THE RESET BAR TO CLEAR IT.
    SELECT USER REQUEST FILE(S) FROM THE APPROPRIATE PULL-DOWN MENU(S).
    CLICK ON THE RUN BUTTON(S) IN THAT LINE(S).
    CLICK ON THE "GO" BAR.

4. TO ACCESS CREME96 UTILITIES:
    CLICK ON THE RUN BUTTON ON THAT LINE.
    CLICK ON THE "GO" BAR.

NOTE: YOU CAN CREATE OR EDIT ONLY ONE USER REQUEST FILE AT A TIME. BUT YOU CAN
SUBMIT SEVERAL FILES FOR RUNNING (SEQUENTIALLY, IN THE ORDER SHOWN IN THE TABLE)
BY CHECKING MORE THAN ONE "RUN" BUTTON AND THEN CLICKING ON THE "GO" BAR.

QUESTIONS? COMMENTS? SEND MAIL TO tylka@crs2.nrl.navy.mil.

YOU MAY TERMINATE YOUR CREME96 SESSION AT ANY TIME.

FIG. 10